

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
1 March 2001 (01.03.2001)

PCT

(10) International Publication Number  
**WO 01/14649 A1**

(51) International Patent Classification<sup>7</sup>: E02F 3/92, 3/88, 5/28

(21) International Application Number: PCT/GB00/03208

(22) International Filing Date: 21 August 2000 (21.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 9919801.2 21 August 1999 (21.08.1999) GB

(71) Applicant (for all designated States except US): PSL TECHNOLOGY LIMITED [GB/GB]; Badentoy Avenue, Portlethen, Aberdeen AB12 4YB (GB).

(71) Applicant and  
(72) Inventor: LANE, Richard [ZA/ZA]; 116 Chelsea Lane, Chelsea, Port Elizabeth (ZA).

(72) Inventor; and  
(75) Inventor/Applicant (for US only): BROWN, Phil [GB/GB]; Badentoy Avenue, Portlethen, Aberdeen AB12 4YB (GB).

(74) Agent: KENNEDYS PATENT AGENCY LIMITED: Floor 4, Queens House, 19-29 St Vincent Place, Glasgow G1 2DT (GB).

(81) Designated States (national): AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EE, EE (utility model), ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

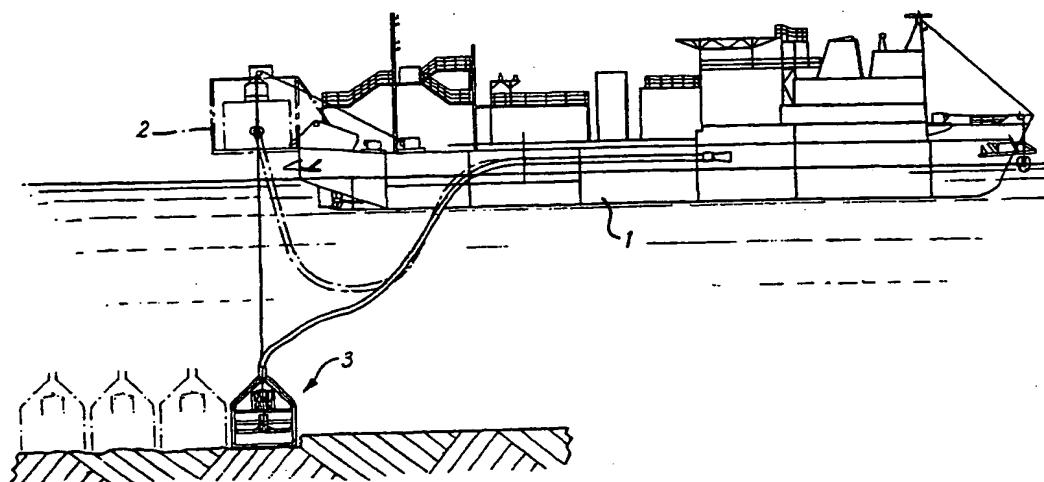
(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— With international search report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR SEA BED EXCAVATION



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(57) Abstract: A sea-going vessel (1) provided with hoisting equipment (2) is employed for the controlled lowering and raising of excavation apparatus (3). The excavation apparatus (3) comprises a chamber (4) within which is contained agitation and suction means. The agitation means may comprise a propeller (9) employed to produce a high speed jet of sea water directed at the sea bed. Both agitation and suction means are controlled by communication means with the vessel (1). A method is described whereby an area of the sea bed is isolated by deployment of the chamber (4). Thereafter the sediment is disturbed by the agitation means before said disturbed sediment is conveyed to the vessel (1), for processing, by the suction means.

1 **Apparatus and Method for Sea Bed Excavation**

2

3 The present invention relates to improved method and

4 apparatus for enabling the extraction of sediment and

5 other particulate materials from the sea bed.

6

7 In this specification, references to the sea bed should

8 be construed broadly, and as such should be deemed to

9 include river beds, lake beds and the like.

10

11 There are various applications, motivated by both

12 environmental and commercial considerations where it may

13 be beneficial to excavate an underwater sea bed. For

14 example, diamonds occur in certain rock and sediment

15 formations lying below the surface of the sea bed. This

16 is the case on the southern west coast of Africa, where

17 typically the highest concentrations of diamond deposits

18 lie between approximately 0.3 metres and 0.8 metres below

19 the gravel layer surface. Apparatus is required for

20 extracting the top layer, preferably to a depth of

21 approximately one metre, to allow the diamonds to be

22 mined.

23

1 Another application lies in the dredging of harbours or  
2 ports where the constant use of oil-based fuels to power  
3 marine craft leads to the polluting of the sea bed;  
4 creating the desire to provide a means for the periodic  
5 lifting and filtering or other cleaning of the sea bed  
6 material. A yet further application that is envisaged in  
7 consequence to growing environmental concerns relates to  
8 the extraction of drill cuttings in the vicinity of off-  
9 shore drilling sites.  
10

11 The present invention is not limited to these  
12 applications but finds utility in any situation where it  
13 might be advantageous to excavate the sea bed. Usually,  
14 this will also involve the raising of the sea bed  
15 particles or other matter to the surface where would be  
16 positioned a ship or boat housing the means for  
17 performing some operation such as cleaning or separating  
18 the matter, for example.  
19

20 In the art there are provided diverse means for  
21 excavating sea beds. One such means that is used in  
22 fairly loosely compacted sea beds involves the use of one  
23 or more suction units that are dragged by an overhead  
24 ship across the sea floor. Suction is provided by  
25 pumping apparatus located on the ship. However this  
26 technique is associated with a number of disadvantages,  
27 including the relative low efficiency of employing  
28 suction as a sole means to encourage the dislodging and  
29 uplifting of sea bed material. Movement of the suction  
30 means in loosely defined linear paths also leads to poor  
31 surface coverage of the entire sea bed; there inevitably  
32 being gaps between the linear paths and inconsistencies  
33 in the depth of penetration of the apparatus. Dragging  
34 heavy equipment across the sea bed may also lead to the

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1 inadvertent damage of pipelines or other sub sea  
2 structures.

3  
4 It is an object of the present invention therefore to  
5 provide an improvement to this technique, and moreover to  
6 offer a systematic method for removing the sediment top  
7 layer of a sea bed with improved sea bed coverage at a  
8 consistent depth.

9 According to the present invention there is provided  
10 apparatus for use on a sea bed, the apparatus comprising  
11 a chamber defining a volume of sea water located above an  
12 area to be excavated, wherein the apparatus further  
13 comprises agitation means located within the chamber for  
14 agitating the sea bed in the said area and one or more  
15 suction means for receiving sediment or other sea bed  
16 material agitated by said agitation means.

18 Preferably the chamber is substantially open at a lower  
19 part thereof.

21 Alternatively the chamber is partially closed at a lower  
22 part thereof by a flexible membrane and securing means,  
23 wherein the flexible membrane defines an enclosed  
24 passageway between the chamber and the sea bed.

26 The suction means may communicate with one or more rigid  
27 or flexible delivery risers for conveying the sea bed  
28 material to a vessel or platform located on the sea  
29 surface. Typically the vessel or platform would be  
30 provided with pumping equipment for generating suction in  
31 the suction means.

1 The chamber preferably acts as a barrier to contain the  
2 agitated material from the sea bed within a volume  
3 defined by the chamber. This serves to increase the  
4 efficiency of the apparatus in that the disturbed sea bed  
5 material is captured in the excavation area such that it  
6 is maintained as available for collection by the suction  
7 means.

8

9 The agitation means is preferably a device for jetting  
10 sea water at the sea bed. It may for example comprise of  
11 a hydraulically driven propeller that is adapted to  
12 propel sea water within the chamber forcibly toward the  
13 sea bed. The propeller would encourage a circular flow  
14 of water in a horizontal plane, but other means may also  
15 be included, such as vanes, fins, to encourage such  
16 circular flow.

17

18 Alternatively, the agitation means comprises mechanical  
19 blades or other members adapted to agitate the sea bed by  
20 consequence of physically impacting the sea bed. A yet  
21 further alternative may be that the agitation means  
22 incorporates a sonic or ultrasonic device.

23

24 Preferably the suction means includes one or more inlets  
25 for the intake of sea bed material, wherein the or each  
26 inlet is disposed toward the perimeter of the chamber.  
27 Most preferably, an inlet is provided at each corner of  
28 the lower open side of the chamber.

29

30 The chamber may be further provided with a vent to  
31 balance the volume of water in the chamber. The vent may  
32 be associated with a valve or plug such that the vent is  
33 kept open in normal operation, but in the event that the  
34 apparatus becomes trapped in the sea bed can be closed

1 enabling the suction process to be reversed thus freeing  
2 the apparatus. Reversal of the suction process may  
3 involve the use of the agitation means.

4

5 Preferably, the chamber has a skirt at the lower edge of  
6 its side walls, the skirt being robust and resilient.

7

8 According to a second aspect of the invention there is  
9 provided a method of excavating a sea bed comprising the  
10 steps of isolating an area of the sea bed; agitating the  
11 sea bed in the said area and sucking the agitated sea bed  
12 material to a surface vessel or the like.

13

14 Preferably the area is isolated by a physical barrier.  
15 The sea bed may be agitated by inducing high velocity  
16 fluid movement inside the isolated area.

17

18 Preferably the said method is conducted for a first  
19 period of time and then repeated for successive periods  
20 in respect of successive areas to be excavated.

21

22 Most preferably each successive excavation area is  
23 adjacent the preceding area such that optimum coverage of  
24 the sea bed is performed.

25

26 In order to better convey the invention embodiments will  
27 now be described by way of example only with reference to  
28 the accompanying Figures, in which:

29

30 Fig.1 shows a schematic elevation of a subsea  
31 diamond mining system;

32

33 Fig. 2 shows in elevation excavation apparatus in  
34 accordance with the invention;

2 Fig. 3 is a plan view of the excavation apparatus  
3 illustrated in Fig. 2;

4 Fig. 4 is a computer generated simulation of the  
5 movement of sea water and sea bed material inside  
6 the chamber of Figs. 2 and 3;

8 Fig. 5 is a plan view of an alternative embodiment  
9 of the excavation apparatus illustrated in Fig. 2;  
10 and

12 Fig. 6 shows in elevation an alternative embodiment  
13 of the excavation apparatus in accordance with the  
14 invention;

16 With reference firstly to Fig. 1, a sea going vessel 1 is  
17 provided with hoisting equipment 2 for the controlled  
18 lowering and raising of excavation apparatus, generally  
19 depicted at 3. The vessel may be provided with means for  
20 separating diamonds or material including diamonds from  
21 other waste material obtained from the sea bed. It  
22 should be appreciated that such means are not critical to  
23 the present invention; the invention hereto being  
24 concerned with the efficient and systematic collection of  
25 excavated material from the sea bed.

27 The excavation apparatus 3 is more clearly depicted in  
28 Figs. 2 and 3. The apparatus 3 includes a chamber 4  
29 formed substantially as a cube, but with an open lower  
30 side. The lower side 5 is therefore approximately  
31 square, and in the example embodiment is dimensioned with  
32 sides of 5 metres.

34

1 A twenty inch diameter lift line 6 feeds into the chamber  
2 and divides via a manifold into four arms 7, each arm 7  
3 terminating with an inlet 8. The line 6 provides a  
4 suction medium for sucking and conveying sea bed material  
5 up to the vessel 1.

6

7 Descending through the centre of the chamber is a  
8 relatively powerful water driven propeller 9. The  
9 propeller 9 is adapted to thrust sea water downwardly and  
10 forcibly onto the sea bed. The momentum of the propelled  
11 sea water is sufficient to agitate the sea bed to such  
12 extent as to cause sediment and other particles to  
13 unsettle and travel around the chamber 4. It will be  
14 appreciated that the rotary action of the propeller 9  
15 will cause the sea water and agitated sea bed material to  
16 move in a swirling direction, which will encourage the  
17 sea bed material to migrate to the corners of the chamber  
18 4. Accordingly, the suction inlets 8 are ideally located  
19 at these corners for the efficient collection of the sea  
20 bed material.

21

22 This may be more clearly demonstrated by Fig. 4 which  
23 illustrates a simulation of the movement of the seabed  
24 material in the chamber 4. The velocity of the material  
25 is dependent on its location in relation to both the  
26 propeller 9 and the suction inlets 8. Accordingly,  
27 material located directly under the propeller 9 and  
28 towards the centre of the sides of the chamber 4 is  
29 affected least, while the material located towards the  
30 edges of the propeller 9 and adjacent to the suction  
31 inlets 8 is displaced most.

32

33 In an alternative embodiment, the chamber 4 may be  
34 provided with means to improve the swirling effect of the

1 propeller 9 to ensure that the seabed within the area of  
2 the chamber 4 is efficiently agitated. Figure 5  
3 illustrates such an alternative embodiment where baffles  
4 or directing blades 10 positioned below the propeller 9  
5 are used to achieve this effect.

6

7 A further embodiment of the chamber 4 may be provided  
8 such that a flexible membrane 11 and chain 12 are  
9 incorporated on the lower side 5 of the chamber. Such an  
10 embodiment is illustrated in Figure 6. The flexible  
11 membrane 11 is employed to define a shallow passageway 13  
12 across the sea bed. The propeller 9 is then used to  
13 generate a high velocity water flow across the sea bed.  
14 The water flow enters the passageway 13 at the inlet 14  
15 before passing into the suction inlet 8 at the other end.  
16 As the water flow passes through the passageway 13 it  
17 carries with it sediment so permitting excavation of the  
18 sea bed. The chain 12 is employed to weigh down the  
19 flexible membrane 11 and so stop it billowing upwards  
20 when the high velocity water flow passes underneath.

21

22 As the sea going vessel 1 passes over the area to be  
23 excavated, the apparatus 3 is placed such that the  
24 chamber 4 is stationary on the seabed. The sediment is  
25 then agitated by the action of the propeller 9. The  
26 suction arms 7 draw the sediment through the inlets 8 to  
27 the vessel 1. Agitation of a single area is typically  
28 done for 30-45 seconds depending on the nature of the sea  
29 bed to allow an appropriate depth to be excavated.

30

31 Once in the vessel 1 the sediment can be filtered to  
32 remove the desired material, such as diamonds, and  
33 subsequently returned to the sea bed. The apparatus is  
34 then translocated to a neighbouring section of the sea

1 bed and the process is repeated. The design of the  
2 apparatus is such that the entire sea bed can be covered  
3 improving the overall efficiency of the process.

4

5 Although unlikely, it might be possible as a result of  
6 the agitation process that the apparatus can sink into  
7 the sea bed and can become stuck. Accordingly, the  
8 chamber 4 is also provided with a valve (not shown) which  
9 is open during normal operation. However, in the event  
10 that the apparatus becomes stuck in the sea bed the valve  
11 can be closed and the suction process reversed to free  
12 the apparatus. Potentially, this may be achieved in two  
13 ways, namely: 1) the suction through the lift line 6 may  
14 be replaced by downward flow, or 2) the suction through  
15 the lift line may be deactivated and the upward reaction  
16 force of the propeller 9 be relied upon.

17

18 It will be noted from the example embodiments that the  
19 agitation of the sea bed is achieved without causing any  
20 direct impacting of the agitation device on the sea bed.  
21 This mitigates the possibility of damaging any existing  
22 structures that might pre-exist on the sea floor.

23

24 A further advantage of the present invention is that  
25 there is provided apparatus with improved  
26 capacity/efficiency for excavating a sea bed or the like  
27 as a result of improved coverage, higher concentration of  
28 material entering the suction arms and deeper penetration  
29 of the bed.

30

31 Further modifications and improvements may be added  
32 without departing from the scope of the invention herein  
33 intended.

1 CLAIMS

2

3 1) Apparatus for use on the sea bed comprising a chamber  
4 defining a volume of sea water located above an area  
5 to be excavated, wherein the apparatus further  
6 comprises agitation means located within the chamber  
7 for agitating the sea bed in the said area and one or  
8 more suction means for receiving sediment or other  
9 sea bed material agitated by said agitation means.

10

11 2) Apparatus for use on the sea bed as claimed in Claim  
12 1 wherein the chamber is substantially open at the  
13 lower end thereof.

14

15 3) Apparatus for use on the sea bed as claimed in Claim  
16 1 wherein the chamber is partially closed at the  
17 lower end thereof by a flexible membrane and securing  
18 means, wherein the flexible membrane defines an  
19 enclosed passageway between the chamber and the sea  
20 bed.

21

22 4) Apparatus for use on the sea bed as claimed in any of  
23 the preceding claims wherein the suction means may  
24 communicate with one or more rigid or flexible  
25 delivery risers for conveying the sea bed material to  
26 a vessel or platform located on the sea surface.

27

28 5) Apparatus for use on the sea bed as claimed in any of  
29 the preceding claims wherein the vessel or platform  
30 would be provided with pumping equipment for  
31 generating suction in the suction means.

32

33 6) Apparatus for use on the sea bed as claimed in any of  
34 the preceding claims wherein the chamber acts as a

1 barrier to contain the agitated material from the sea  
2 bed within a volume defined by the chamber so  
3 increasing the efficiency of the apparatus.

4

5 7) Apparatus for use on the sea bed as claimed in any of  
6 the preceding claims wherein the agitation means is a  
7 device for jetting sea water at the sea bed.

8

9 8) Apparatus for use on the sea bed as claimed in Claim  
10 7 wherein the agitation means is a hydraulically  
11 driven propeller.

12

13 9) Apparatus for use on the sea bed as claimed in Claim  
14 7 and 8 wherein the agitation means employs means for  
15 directing the jetting sea water.

16

17 10) Apparatus for use on the sea bed as claimed in Claim  
18 9 wherein the means for directing the jetting sea  
19 water are one or more vanes.

20

21 11) Apparatus for use on the sea bed as claimed in Claim  
22 9 wherein the means for directing the jetting sea  
23 water are one or more fins.

24

25 12) Apparatus for use on the sea bed as claimed in Claims  
26 1 to 6 wherein the agitation means comprises  
27 mechanical blades or other members adapted to agitate  
28 the sea bed by consequence of physically impacting  
29 the sea bed.

30

31 13) Apparatus for use on the sea bed as claimed in Claims  
32 1 to 6 wherein the agitation means is a sonic or  
33 ultrasonic device.

34

1 14) Apparatus for use on the sea bed as claimed in any of  
2 the preceding claims wherein the suction means  
3 includes one or more inlets for the intake of sea bed  
4 material.

5

6 15) Apparatus for use on the sea bed as claimed in any of  
7 the preceding claims wherein the or each inlet is  
8 disposed toward the perimeter of the chamber.

9

10 16) Apparatus for use on the sea bed as claimed in any of  
11 the preceding claims wherein the chamber comprises a  
12 vent to balance the volume of water in the chamber.

13

14 17) Apparatus for use on the sea bed as claimed in any of  
15 the preceding claims wherein the vent is associated  
16 with a valve or plug such that the vent is kept open  
17 in normal operation, but in the event that the  
18 apparatus becomes trapped in the sea bed can be  
19 closed enabling the suction process to be reversed  
20 thus freeing the apparatus.

21

22 18) Apparatus for use on the sea bed as claimed in any of  
23 the preceding claims wherein the reversal of the  
24 suction process involves the use of the agitation  
25 means.

26

27 19) Apparatus for use on the sea bed as claimed in any of  
28 the preceding claims wherein the chamber has a skirt  
29 at the lower edge of its side walls, the skirt being  
30 robust and resilient.

31

32 20) A method of excavating a sea bed comprising the steps  
33 of:

34 1. Isolating an area of the sea bed;

1       2. Agitating the sea bed in the said area;  
2       3. Sucking the agitated sea bed material to a surface  
3       vessel or the like.

4

5       21) A method of excavating a sea bed as claimed in Claim  
6       20 whereby the area is isolated by a physical  
7       barrier.

8

9       22) A method of excavating a sea bed as claimed in Claim  
10      20 and 21 whereby the sea bed is agitated by inducing  
11      high-velocity fluid movement inside the isolated  
12      area.

13

14      23) A method of excavating a sea bed as claimed in Claims  
15      20 to 22 whereby the said method is conducted for a  
16      first period of time and then repeated for successive  
17      periods in respect of successive areas to be  
18      excavated.

19

20      24) A method of excavating a sea bed as claimed in Claim  
21      23 whereby each successive excavation area is  
22      adjacent to the preceding area such that optimum  
23      coverage of the sea bed is performed.

## INTERNATIONAL SEARCH REPORT

Int'l. Searcher Application No.  
PCT/GB 00/03208

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 428 (M-1307), 8 September 1992 (1992-09-08) & JP 04 146333 A (UBE IND LTD), 20 May 1992 (1992-05-20) abstract figures 1-3,7 ---	1,2,4-6, 14, 19-21, 23,24
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# INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB 00/03208

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 E02F3/92 E02F3/88 E02F5/28

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 E02F A01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 1 719 668 A (MC EACHERN) 2 July 1929 (1929-07-02)	1,2,4,6, 7,14,20, 21
A	page 1, line 1 - line 17 page 1, line 38 - line 88 figures ---	9,22-24
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		-/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the international search

31 October 2000

Date of mailing of the international search report

08/11/2000

Name and mailing address of the ISA

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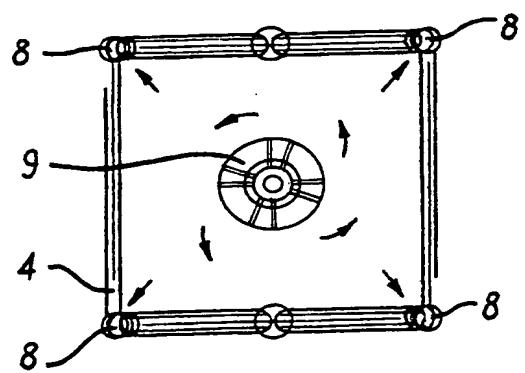
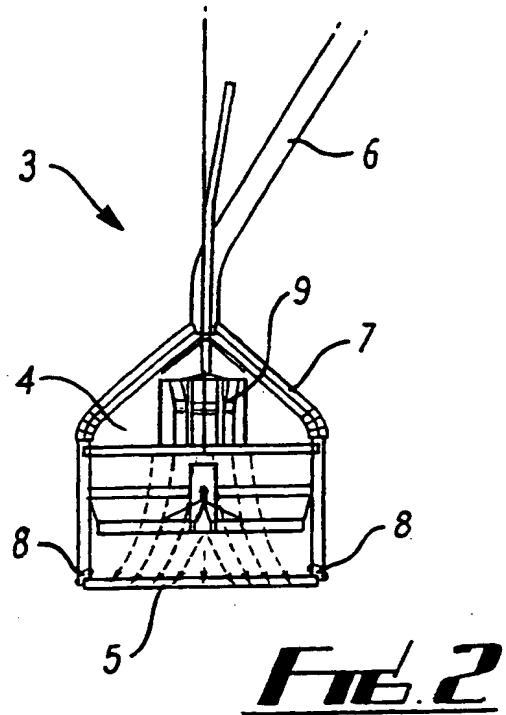
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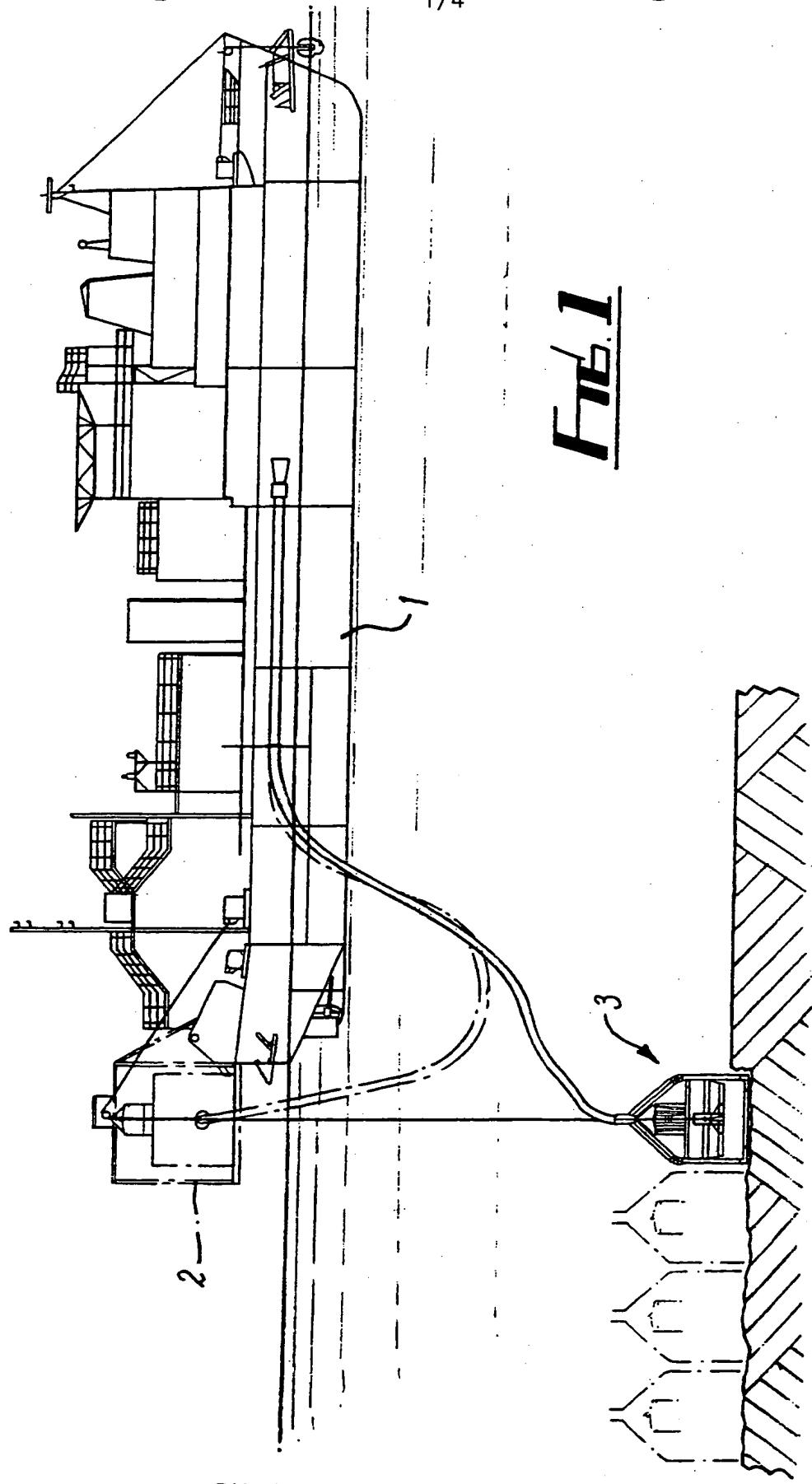
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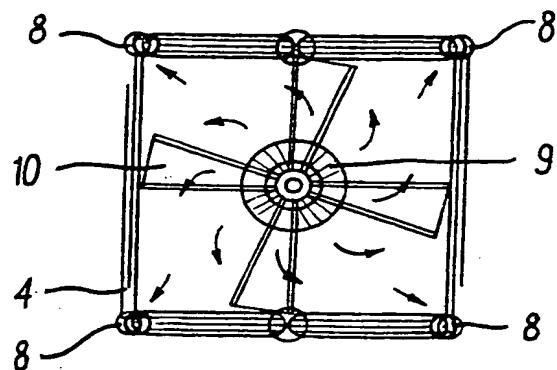
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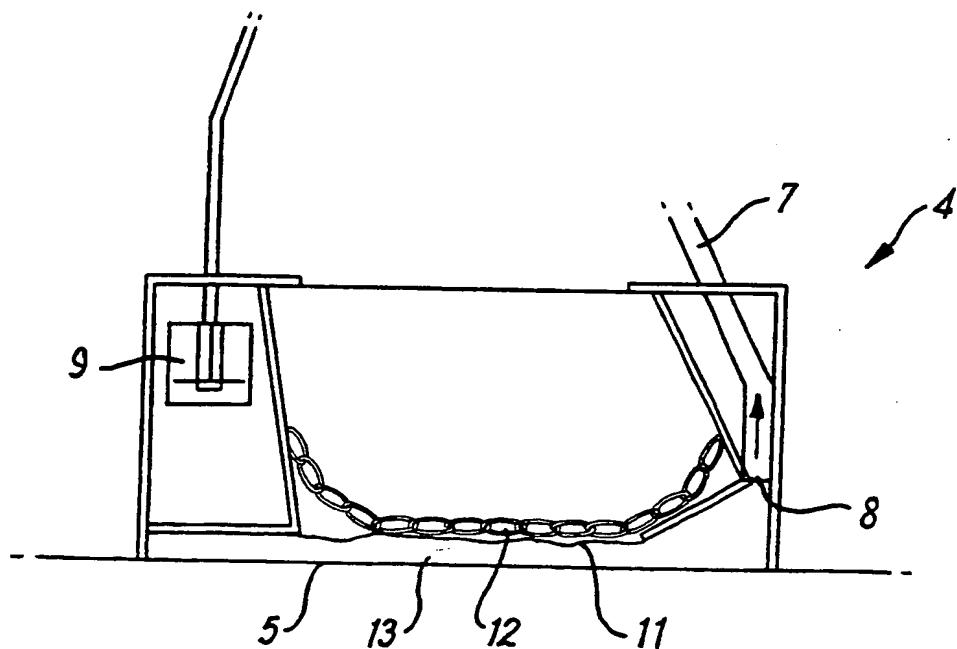




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**FIG. 5**



**FIG. 6**

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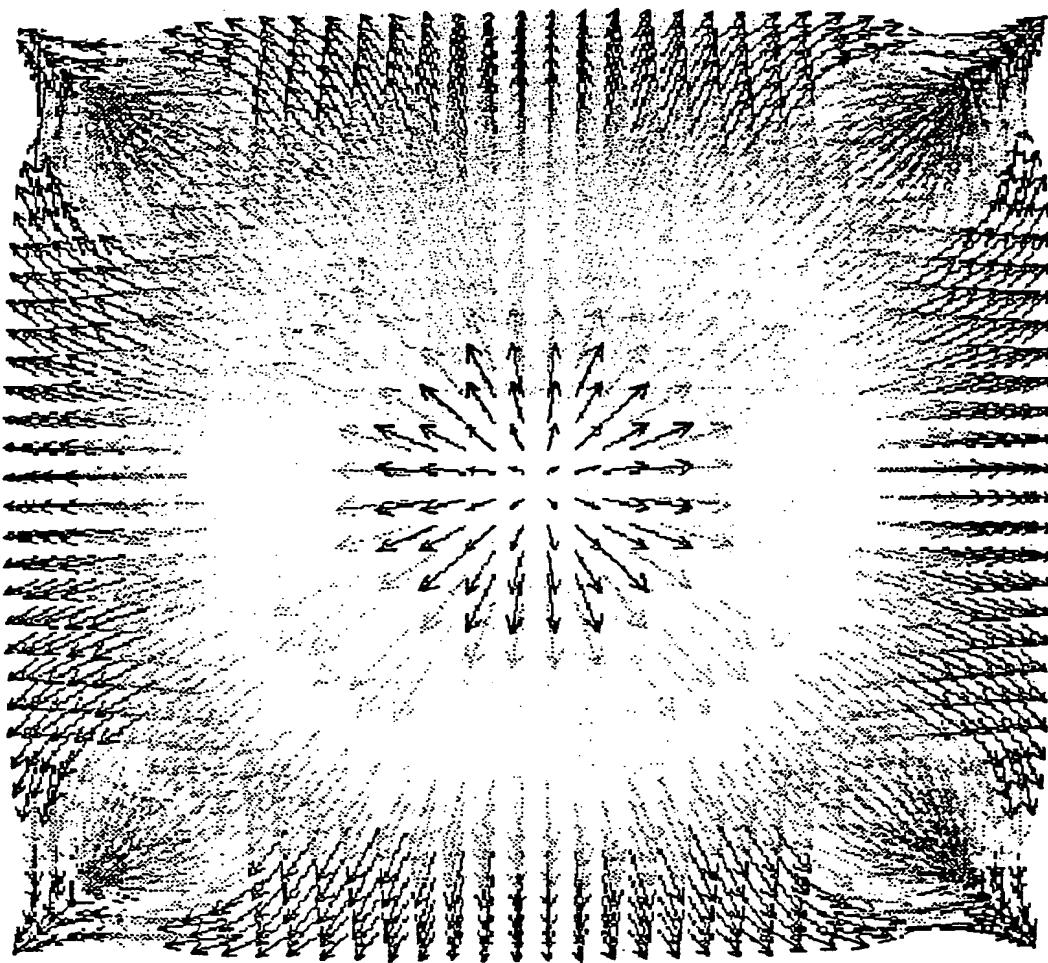


Fig. 4

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